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16. Abstract <p>The chief objective of this project is to determine the feasibility of detecting large Alaskan archaeological sites by satellite remote sensing techniques, and if that can be accomplished, perform mapping of such sites within Alaska. The approach used is to develop digital multi-spectral signatures of dominant surface features including vegetation types, exposed soils and rock, hydrological patterns and known archaeological sites. ERTS scenes are then printed out digitally in a map-like array with a letter reflecting the most appropriate classification representing each pixel.</p> <p>During the first 6-months period, preliminary signatures were developed and tested. It was determined that there was a need to "tighten up" the archaeological site signature by developing accurate signatures for all naturally-occurring vegetation and surface conditions in the vicinity of the test area. These second-generation signatures have been tested by means of computer printouts and classified tape displays on the U of A CDU-200 and by comparison with aerial photography.</p> <p>We have concluded that the archaeological signatures now in use are as good as we can develop. Plans for the next 6-months' reporting period are to print out signatures for the entire test area and locate on topographic maps the likely locations of archaeological sites within the test area.</p>		13. Type of Report and Period Covered Type II January 1973-July 1973	
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I. INTRODUCTION

This report summarizes the work performed and conclusions reached during the second six months of contract No. NAS 5-21833, ERTS-1 Project No. 110-14, "A Feasibility Study for Locating Archeological Village Sites by Satellite Remote Sensing Techniques".

During this reporting period we have concentrated on developing better signatures for archeological sites and vegetation types as well. Of necessity we have developed methods which can be used by investigators who wish to map natural vegetation in as much detail as possible. We have tested the resulting signatures by both computer print-outs and classified tape displays on the U of A CDU-200 and by comparison with aerial photography. We have concluded that the archeological signatures now in use are as good as we can develop. The results to date have been presented at the 24th annual Alaska Science Conference.

Our principal objective during this reporting period has been to "tighten-up" the archeological site signature by developing accurate signatures for all naturally-occurring vegetation and surface conditions in the vicinity of the test area. This has been accomplished to a reasonable degree of satisfaction.

Progress to date is approximately on schedule, and we anticipate no problem completing the work within the contract time.

II. STATUS OF THE PROJECT

A. General

We have now completed development of all signatures to be used in the analysis of our test area. Work is progressing at a rate equivalent to 1/3 investigator time between this time and project termination. Checks between NASA-provided aerial photography and signature print-out are being made to determine how well the auxilliary signatures (vegetation) correctly

identify features on the ground. By this means, a significant fraction of pixels with false archeological site signatures will be eliminated from consideration.

B. Objectives

1. DEFINITION OF PROBLEM:

The archaeological and historical demographic problem is that of knowing the prehistoric distribution and movements of people in Alaska. This knowledge has been severely limited by lack of comprehensive information concerning location and distribution of former population centers. Comprehensive studies even by aircraft would be too expensive for an area even the size of Western Alaska where this study is concentrated. If feasible from a data interpretation point of view, a broad survey utilizing satellite remote sensing techniques would lead to more intensive surveys of the most promising areas utilizing aircraft.

It is hoped that this feasibility study will determine methods by which large archeological village sites can be mapped in a comprehensive and systematic manner.

2. SCIENTIFIC, TECHNOLOGICAL AND APPLIED OBJECTIVES: The direct scientific objectives of this project are those of archaeology and historical demography outlined under the previous heading.

The technological objectives are to study the feasibility of applying multispectral image interpretation techniques to the detection of archaeological village sites. The fact that the ERTS multispectral scanner data must be used at its highest spatial resolution implies a need for a refinement of analytical and interpretive techniques.

Technological and analytical achievements in signature identification for various Alaskan plant species at high spatial resolution would be relevant and valuable for several other projects in the U of A ERTS program. This technological problem relates to the author's current activities in

photometry and image interpretation, and represents his primary objective in this program.

C. Accomplishments During the Reporting Period

1. Preliminary Analysis

Detailed analysis of first signature print-out. As reported in the previous 6-month's progress report a print-out of preliminary signatures had been performed. This was examined in detail to determine how realistic the locations identified as archeological sites appeared. A moderately large number of picels had been identified as archeological sites, many of which were obviously not sites (based on location). Although it may have been possible to determine likely archeological sites by means of this technique, it appeared to be too subject to error.

2. Approach to problem

a. General

It was determined to approach the problem by developing a second generation of signatures for as many surface features and vegetation types as possible. The relationship of archaeological site signatures to other vegetation signatures could be accurately determined and hopefully the range of signatures used for archaeological sites could be decreased while retaining those signatures with the greatest likelihood of being archaeological sites.

b. Technique

A zoom Transfer Scope was used to superimpose picel-by-picel intensity level print-outs with NASA-provided aerial photography of the test area. The intensity levels in all bands were then transferred to a picel map ruled into squares sufficiently large to write these numbers and a notation of the vegetation

type or types found in the area on the ground represented by that picel.

Next, correlation scatter plots in band 5 vs band 7 and band 6 vs band 7 were prepared. The scatter plots were approximately 4 x 4 ft square and ruled into squares so that for each intensity-level combination there was room to note the number of picels with that combination and the vegetation types in that picel as recognized from aerial photography and ground truth.

These scatter plots were then overlaid with tracing paper and the general domains of each recognizably distinct signature delineated. The signatures thus determined were then used to produce a new thematic computer print-out of the test area.

3. Results

a. signature development. Figure 1 shows the plots of generalized signature domains described in the previous section. The meaning of the symbols, and intensity level range for each signature are given in table 1. As the table shows, most of the signatures developed are for mixtures of vegetations and surface features. This is because in this test area rarely are pure vegetation types or surface features found in the area of a single picel. Indeed, the archaeological sites themselves consist of a mixture of vegetation types.

b. Signature Print out.

Figures 2 and 3 show identical portions of ERTS scene 1002-21315 signature print-outs. Figure 2 shows the print-out performed on the basis of the preliminary signatures reported in our first semi-annual report while figure 3 is a print-out based on the new signatures reported here. The new print-out has been shaded according to vegetation types. The following paragraphs contain a discussion of the newly-developed signatures.

1. Water Course Signatures. The major change here has been to identify a signature for the bank of the Khotol River and sloughs. Formerly the Khotol River signature was given a rather broad range of definition with the result that picels containing both the Khotol and a significant fraction of riverbank were registered as "K". Here, we have narrowed down the range of definition so that only picels located in the center of the Khotol River are represented by "K" and picels located on its bank are represented by "B". Note that generally the "Bank" signature is represented on one side of the river or the other.

11. Vegetation Signatures. As can be readily seen, the new print-out contains signature symbols for more vegetation type identifications than the old. Further, almost none of these new signatures are for a pure vegetative type. Here we will discuss each of these new signatures.

P. Stands of predominately large spruce trees. Picels printed out with a "P" are shaded darkest of figure 3. These are generally trees of sufficient size to be considered of potential commercial value. Comparison with NASA-provided aerial photography shows this signature to be reasonably accurate. (See discussion of "T").

T. Large trees (combinations of spruce, birch and aspen). Although not shown in figure 1, band 4 was found to have utility in differentiating between T and P signatures. This differentiation is reasonably good with its greatest deficiency being that band 4 is subject to relatively poor intercalibration among the MSS detectors. As a result, there appears to be some error introduced into the T/P decision.

vigorous grasses and willow. The unusually healthy state of these plants results from fertilization, soil mixing and aeration resulting from former habitation activities. (See Dixon and Stringer, 1972).

- Z. Combination of willows, grass and bare ground. This vegetation type is characteristic of much low-lying wet ground and is often interspersed with patches of mud. The mud patches are probably maintained in part by the grazing activities of moose. The tendency toward mud patches is one feature which generally helps distinguish "Z" picels from "A" picels. However, the distinction is not complete as evidenced by several patches of 6's a lower probability archaeological site signature. These patches of 6's should very likely be Z's.
- Q. Combination of water puddles, wet bare ground (mud) and grass. Picels with this signature have been shaded slightly darker than the picels with "O" signatures. Note that the Q's often align themselves in rather long strings. There are several former river channels in this area which now consist of lineated low-lying areas.
- O. Largely grass. There is no clear line of distinction between this signature and "Q". However the choice made appears to have differentiated between two surface conditions in that Q's and O's are not randomly distributed with respect to each other but rather appear in separate groups. Comparison with aerial photography generally bears out the distinction made.
- . Average of general vegetation and sandy bare ground. This signature was found to represent picels located along riverbanks and other areas where moderate expanses of dry sandy soil with perhaps some vegetation occurred.

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iii. Archaeological site signatures

1-4, Signatures of known archaeological sites. The locations of these signatures determine the boundaries of the signature volume labeled "A" in figure 1. Any picel represented by these numbers has the same combination of reflectance levels as a known archeological site. There is the possibility however, that the banding effects mentioned earlier are at least partly responsible for the identification of some picels as 1,2,3 or 4 simply because there are variations of the average intensity level on the order of one unit among the six detectors monitoring each MSS band.

5-7, Signatures approximate to those of known archaeological sites. Considering the intensity levels in bands 5,6 and 7 to define an ordinary orthogonal 3- space, signatures, 1 through 4 define the outline of a 3-dimensional solid. This solid has been subdivided into three smaller volumes labeled 5,6, and 7. The ordering sequence being determined by a subjective judgement was based on the relative proximity to signatures of known sites.

Of the 262,144 picels examined in this portion of ERTS scene 1038-21301, a total of 7,890 or just under 3% were classified as 1 through 3. The most frequent classification was "6" with 4,243 or 1.6% of all picels. It is not believed that these are unreasonably high percentages. Further interpretation of the probability of a picel with a classification of 1 through 7 actually being an archaeological site will depend on its position relative to other classified picels. For instance, the life style of peoples in this area was directly linked to fishing and water transportation. Hence identified picels

at any distance from water courses can be ignored. This additional decision-making process will greatly reduce the number of possible locations of archaeological sites.

III. NEW TECHNOLOGY

Although the methods used here cannot be termed "New Technology" they may be useful to investigators wishing to perform digital analysis of ERTS tapes and who do not have extensive special-purpose data analysis equipment.

IV. PLANS FOR NEXT REPORTING PERIOD

- A. Next Bi-monthly period: The written version of the paper presented at the 24th Alaska Science Conference will be prepared for the Proceedings of the Conference. This paper includes detailed examination of vegetation mapping based on the signatures developed here.
- B. Next six months period: Using signature print-outs discussed here, a map of the locations of probable archaeological sites in the Khotol Flats region of Western Alaska will be prepared. Comparison of indicated sites with known sites will be made. A preliminary evaluation of the feasibility of locating Alaskan archaeological sites will be made and reported in the Final Report of this project.

V. CONCLUSIONS

The second generation of signatures developed during this reporting period have shown the improvement in quality desired in order to proceed with mapping of archaeological sites in the Khotol Flats area.

VI. RECOMMENDATIONS

None.

VII. PUBLICATIONS

The paper "Remote Sensing of Alaskan Archaeological Sites -II Digital Analysis of ERTS Data." was presented at the 24th Alaskan Science Conference (The regional AAAS meeting) in August, 1972.

VIII. REFERENCES

Dixon and Stringer, 1972, "Remote Sensing of Alaska Archaeological Sites: A Preliminary Report." presented at the 23rd Alaskan Science Conference. Manuscript may be obtained from the authors.

APPENDICES

Appendix A - Change in Standing Order Forms

None

Appendix B - ERTS Data Request Forms

None

Appendix C - ERTS Image Descriptor Forms

None

Appendix D - Significant Results

Attached

-112-

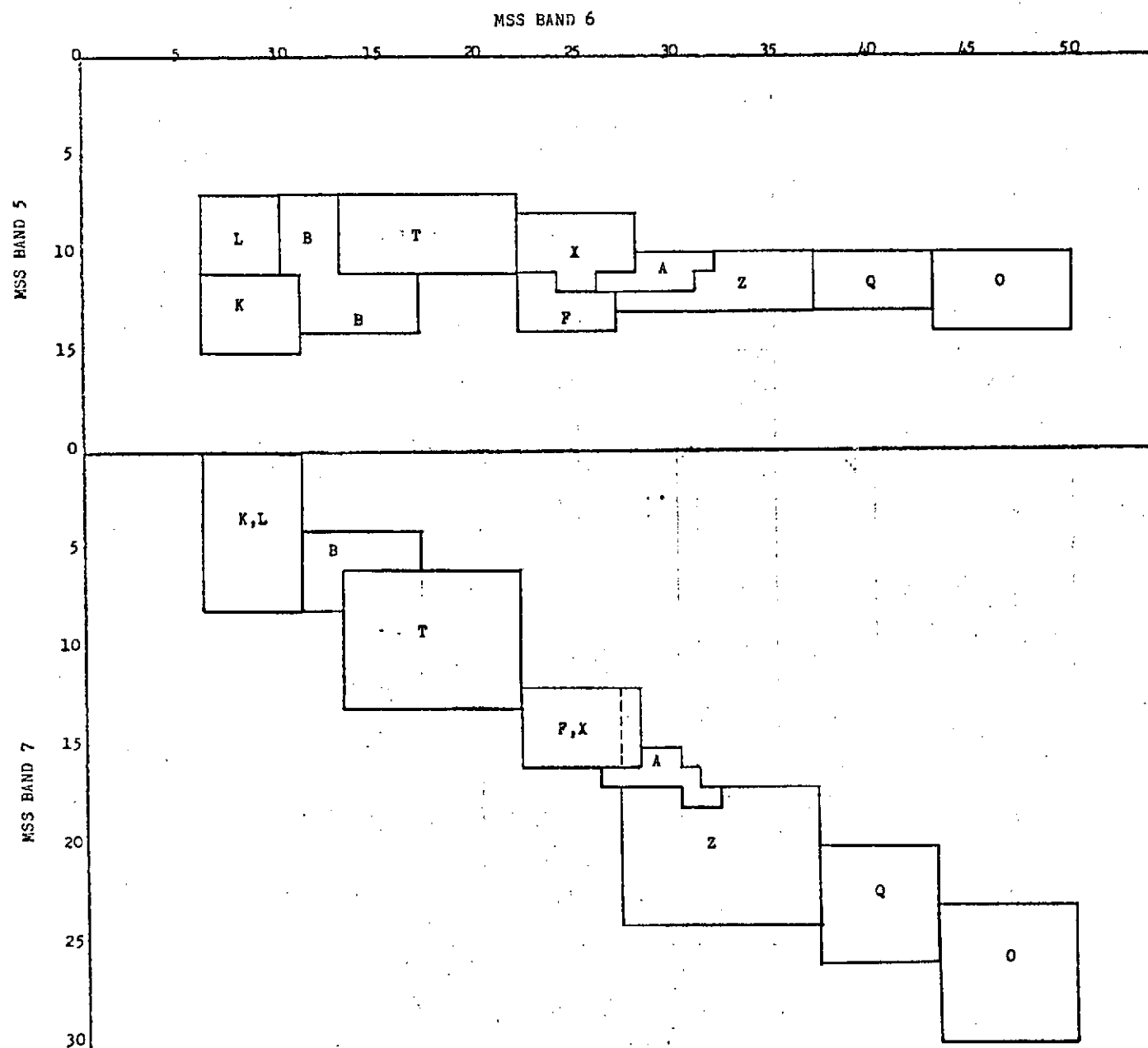


Figure 1. Two-dimensional projections of 3-dimensional signature domains. Considering digital reflectance levels in MSS bands 5, 6 and 7 as coordinant magnitudes, the idealized domains of each identifiable signature have been delineated. These two projections may be considered as a "top" and "side" view of a series of 3-dimensional domains. All picels with the combinations of intensity levels in each domain are identified on signature plots by the letter shown on that domain.

SSSS	6557	WWWW		W
TLLSSSSSSSSSSSSSSSSSSSSSS	WWWWW	75		W
WWWWW	WSSSSLL	TTTTLSSSSS	WW	
SSSSSSSL	75WW	WWWTTWW	SSSSWWW	
LLLLLL	WW	WW	W8GWTLTWLSSSTWW	5 W W W
WWWWWWWWW	WGGWWW	WTWSSSW		W
WWWWWWWWW	WW	GWW7G8	L SSW	
WWWWWWWWW	W8GGG	GWW6G	TTTTSS	8WWW WW W5
WWWWGGG	GGG	WGGWW	GG TT	SSSW W
W5GG	GGGG	GGGG	GWWWWGGWWTTTSS	W
GGGGGGGGGGGGGGGGGGGG	8G7WWW	W8	T SSSWWW	
GGGGGGGGGGGGGGGGGGGG	WWW7	57TTTTSSW		
GGGGGGGGGGGGGGGGGGGG	WWW	W8W	T SS	NW 5W
8GGGGGGGGGGGGGGGGGGGG	8WW	W86WG8	ITWSSSTWW	WTT
G8	GGGGGGGGGGGGGGGGGGGG	WWW5	7 8 SSSW	WTT
GGG	GGST	GGBGGG	W WWW5GGT	TSSSW WTT W
BGGGGG	1L2G	WGBGGG	8WW8 WWW	GWWWTSSSW WLTWW
B8888GG	T 8	B88G	WW5 WWW	8W WTSS W WLT
G8888GGG	8GGGGGGG	8	W WW5	TSS 85W
B88888GGGGGGGGGGGGGG	GG3W	63 W	WL 7	TWSSW WWW 7WW
GG88GGGGGGGGGGGGGGGG	W88	WTW	8WT SS	5W W
G	GGGGGGGGGGGGGGGGGGGG	GGG	G6W W	GW TWSS WWW
TW	GGGGGGGGGGGGGGGGGGGG	8BGGW8G8W	W TT	SS W
TTTT	G88888G	88 W	G WWWWTTWSSS	8
6	WGGGG	G88W8G	WW WWW	SSSW W 67 W
WGGGGW	TTWW6	GGG	T WW	W688WSSST WWTLT WWW
GGGGGG	TT	WWW6L	TWSSSSSSSSSL	WWLLW W W
8GGGGGG	TLTT	TTTSSSSSL	TTWWW	WWW
W5GGGG	TT	TTTSSSLT	WW	W8 WW WWW
GG	8	GWWWTTSSTTWT	WWW	G

Figure 2. Printout of early vegetation signatures in the vicinity of Old Fish Camp. Signatures were derived for slough (of the Yukon River) (S), willows (W), large trees (T), grass (G), bare ground (B), and probability of archaeological site (1-8). The archaeological site probability is greatest for an "8" signature.



Figure 3. Printout of second generation signatures described in text. Here archaeological site probability is inversely proportional to magnitude of numbers 1-7. Groupings of similar signatures have been indicated by shading. Improvement over signature classifications illustrated in Figure 2 include recognition of combinations of vegetation types and identification of greater number of distinct signatures. The quantity of pixels with possible archaeological site identification has been drastically reduced.

SEMI - ANNUAL PROGRESS REPORT

UNIVERSITY OF ALASKA

ERTS PROJECT 110-14

PRINCIPAL INVESTIGATOR: John P. Cook

TITLE OF INVESTIGATION: Feasibility Study for Locating Archaeological
Village Sites by Satellite Remote Sensing
Techniques

DISCIPLINES: Archaeology

SUBDISCIPLINES: Demography, Interpretation techniques development

SUMMARY OF SIGNIFICANT
RESULTS: No significant results this reporting period